GAUSE`S PRINCIPLE WITH FIELD & LABORATORY EXAMPLES

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The Competitive Exclusion Principle, or Gause's law, proposes that two species competing for the same limited resources cannot sustainably coexist or maintain constant population values.

Intraspecific competition, describes when organisms within the same species compete for resources; leading the population to reach carryingcapacity.

Carrying capacity refers to the maximum population size a species can sustain within its environmental limitations.

Interspecific competition describes when competition for resources occurs between different species of organisms. Species can be limited by both their carrying capacity (intraspecific competition) and the interspecific competition.

When two species compete within the same ecological niches, the Competitive Exclusion Principle predicts that the better adapted species, even if only slightly better adapted, will drive the other to local extinction. In the 1930s, biologist Georgy Gause explored the idea of interspecific competition in a ground-breaking study of competition in Paramecium. Paramecia are aquatic single-celled Ciliates that survive on a diet of Bacteria, Yeast, Algae, and other small protozoa. Based on the findings of this experiment and other research, Gause developed the Competitive Exclusion Principle.

Direct or interference Competetion:

Connel's field experiment on the rocky sea coast of Scotland, where larger Barnacle balanus dominates the intertidal area and removes the smaller Barnacle cathamalus. This happened due to competition for space between two species of barnacles, Balanus balanoides and Chthamalus stellatus. Though Chthamalus occupying an upper zone, and Balanus, a lower zone.

Larvae of both species settle and attach over a wider vertical range than the zone occupied by adults. But barnacles are removed because Chthamalus are more tolerant of physical desiccation than Balanus. Connell suggests that the lower limit of distribution of intertidal organisms is usually determined mainly by biotic factors, such as competition with other species and predation, whereas the upper limit is more often set by physical factors, such as dry conditions prevailing during low tides.

Indirect or exploitation competition:

In this investigation, students explore how competition affects population growth, and put the Competitive Exclusion Principle to the test. Following a very similar experiment design to Gause's original Paramecium experiment, students examine two Paramecium species; Paramecium Caudatum and Paramecium Aurelia. These two species make great model organisms to test this principle due to their similarity, and the fact they compete directly for food. However, the two vary in size with Paramecium Caudatum approximately four times the size of Paramecium Aurelia. Students are tasked with growing the two species both separately and together in a culture medium. The three cultures samples are maintained within the exact same environmental conditions, as Gause's law only applies if the ecological factors are constant. Over three weeks, students observe population growth to determine how competition for resources affects population growth.

PREPARATION - BY LAB TECHNICIAN

Preparing Cultures

As soon as your shipment arrives, open the shipping container, remove the Paramecium culture jars, and inspect your culture.

Loosen the lids on the jars and aerate the culture using the supplied plastic pipette.

To bubble air into the water, hold the pipette tip into the culture water and squeeze the bulb. Raise the pipette; releasing the bulb; allowing it to fill with air once again.

Repeat this step four more times to assist in replacing the oxygen depleted during shipping.

Use a different pipette for each culture to avoid contamination if you have more than one.

Lightly place the lid back on the jar; careful not to screw too tightly.

Maintain the culture jar within room temperature (Approx. 21° C), away from direct sunlight. Plan to conduct your experiment with the Paramecium within three days of your shipment arriving. Ensure you have sufficient Paramecium and take into account that some Paramecium may die.

Preparing Workstations

Provide each student workstation with:

Pure cultures of Paramecium Caudatum

Pure cultures of Paramecium Aurelia

Paramecium Culture Medium

3 Deep Petri Dishes

Sedgewick Rafter Cell

Graduated Cylinder

Mosquito Net/CheeseCloth

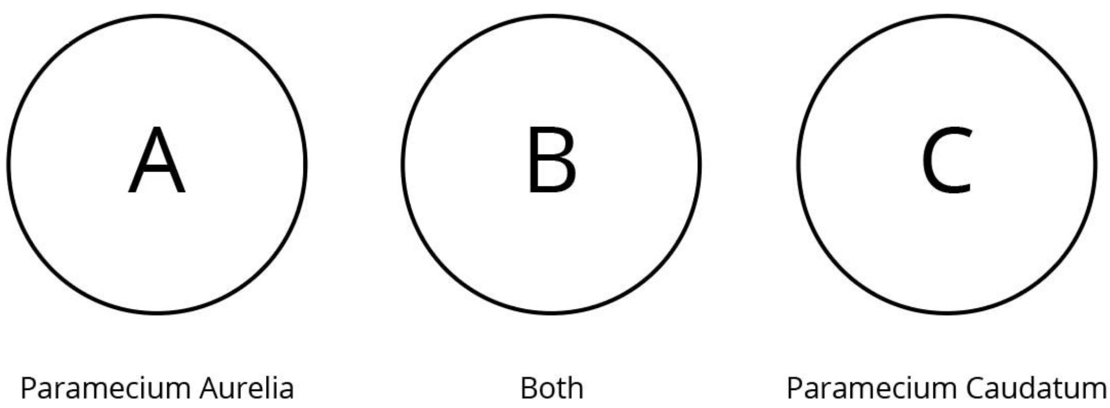
Sterile Plastic Pipettes

Compound Microscope

METHOD - STUDENT ACTIVITY

State your hypothesis.

Label three clean petri dishes as follows.



Add 50mL of Paramecium culture medium to each dish.

Using a graduated cylinder, transfer 20 mL of Paramecium Aurelia into “Petri Dish A”.

Transfer 20 mL of Paramecium Caudatum and 20 mL of Paramecium Aurelia into “Petri Dish B”.

Transfer 20 mL of Paramecium Caudatum into “Petri Dish C”.

Add six grains of rice to the dish to sustain the paramecium and cover each of the petri dishes containing the Paramecium cultures with cheesecloth.

Store the petri dishes at a consistent temperature of 24ºC on a flat surface where they will not be disturbed. Keep away from direct sunlight.

Using a fresh sterile pipette, place 1mL of liquid from each “Petri Dish A” into a Sedgewick Rafter cell.

Using a compound microscope, count the relative number of Paramecium. If the population becomes too dense to count, choose one transect (line of 20 squares representing 20 µL) and multiply by 50 to get the population density per mL.

Return specimens to the Petri dish. This reduces population loss as a result of the counting procedure.

Thoroughly wash the Sedgewick Rafter cell to fully remove all Paramecium specimens.

Repeat steps 9-12 for “Petri Dish B & C”. For "Petri Dish B", count the two species separately. The Paramecium species can be differentiated by their size. Paramecium Caudatum is approximately four times the size of Paramecium Aurelia.

Record your data in a table.

Repeat counting procedure every second day for three weeks and record the results.

OBSERVATION AND RESULTS

Below is an example of expected results based on initial population density of Paramecium were 10 per 1 mL. This is to be used as a guide only as individual results will vary.

		Days (3 weeks)										
		1	3	5	7	9	11	13	15	17	19	21
Separate cultures (Petri Dishes A&C)	Paramecium Aurelia	10	100	230	280	290	250	260	220	250	220	250
	Paramecium Caudatum	10	150	530	740	900	840	980	800	940	970	980
Combined cultures (Petri Dish B)	Paramecium Aurelia	10	70	80	80	70	60	30	15	5	3	0
	Paramecium Caudatum	10	140	330	520	540	600	640	720	600	580	540

Table 1: Expected results

INVESTIGATIONS

Ask students whether their hypothesis was proven correct. Students should provide an explanation as to why/ why not.

Ask students to describe the advantages and disadvantages of this counting technique.

Challenge students to describe limitations in the experiment design. Ask them to suggest ways it can be improved.

Compare the population sizes of each Paramecium species in the separated (A&C) and mixed cultures (B). Ask students what the results reveal about how competition affects population growth.

Ask students to explain whether results prove or disprove the Competitive Exclusion Principle.

EXTENSION EXERCISES

Exponential growth describes population growth that is unlimited. Logistic growth describes growth rates that are limited by a number of factors; including, predators, food scarcity, as well as competition for food and habitat. Which type of growth was exhibited in the Paramecium populations containing only one of the species?